F0132

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

FIRST NAMED APPLICANT: James P. Nadeau

APPLICATION NO.: 10/716,181

FILING DATE: 11/18/2003

TITLE: Method and Apparatus for Controlling Topological Variation on a Milled Cross-Section of a Structure

EXAMINER: Rodney Glenn McDonald

ART UNIT: 1795

DECLARATION OF JAMES P. NADEAU 37 C.F.R. § 1.131

I, James P. Nadeau, declare as follows:

1. I have personal knowledge of the facts stated herein. If called upon I would and could competently testify to these facts.
2. I am a co-inventor of the subject matter of the patent application at issue as referenced above for "Method and Apparatus for Controlling Topological Variation on a Milled Cross-Sectional of a Structure."
3. At the time the subject matter of the patent application at issue was invented, I was an employee of FEI Company of Hillsboro, OR, the assignee of the present application.
4. Along with my co-inventors, I conceived the invention before March 6, 2003.
5. Along with my co-inventors, I reduced the invention to practice before March 6, 2003, as shown by the invention disclosure produced by my co-inventors

Certificate of Transmission under 37 CFR 1.8

I hereby certify that this correspondence is being transmitted by facsimile to the United States Patent and Trademark Office, on this the 14th day of Oct, 2008.

David Griner

and me and dated before March 6, 2003. A true and correct copy of that disclosure with the exact date redacted is attached as Exhibit "A."

I hereby declare that all statements made herein are made of my own knowledge and are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Under penalty of perjury, I declare that the foregoing is true and correct this 13 day of Oct, 2008 in Beaverton, Oregon, US.

Respectfully submitted,

James P. Nadeau

James P. Nadeau

Date: Oct 13, 2008

Exhibit "A"

FEI COMPANY™ *Disclosure Number:* _____ *(To be assigned)*

Invention Disclosure Form

PURPOSE: This form is to be used to document and disclose to FEI Company inventions you have made. If you have questions on when this form should be used, please review the Invention Disclosure Form FAQ available on FEInet or contact the FEI Company Legal Department.

INSTRUCTIONS: Provide answers to each of the sections below to the best of your ability. Once the form is done, please provide an emailed soft copy and a signed hard copy to your division's Intellectual Property Review Board representative (see the "Legal" section of FEInet for more information).

1. **Date:** [redacted]

2. **Invention Title: Improving Precision of SEM Metrology by Eliminating Topographic Artifacts on a FIB Milled Cross Section.**

3. **Primary FEI Contact:** Pei Zou

4. **Commercial Advantage**
   What current or future products would incorporate the invention? How does the invention add value to current or future products or reduce costs?
   - *This invention can be used in all current and future 3-D metrology processes, especially in situations where the cross section area is large in the z-direction (e.g. write head pole metrology for data storage product line) to improve precision, reduce cycle time and improve robustness.*

5. **Dates of Documentation and Disclosures**
   - [redacted]

The initial work to incorporate carbon (C) in a data storage metrology process was documented on [redacted] in an email message by Jason Arjavac. The attached document showed cross section images of recording head poles with carbon as the overlayer. Both the email and the attached document are on file with Jason Arjavac. More systematic carbon deposition work started on [redacted] on the 865-01 tool located in Building 1 in Hillsboro, OR. (Pei Zou's FEI internal notebook, pp. 5). Using carbon in a FIB cross-section started on [redacted] (Pei Zou's FEI internal notebook, pp. 16). The idea of matching FIB milling rates for dissimilar materials to create arbitrary cross section was captured in an internal FEI report dated [redacted] The first attempt to deposit C away from the area of interest was made on [redacted] (Pei Zou's FEI notebook, pp107).

6. Purpose of Invention

What problem is solved by the invention?

Problem Background: SEM Image based metrology relies upon the ability to make measurements between grey level transitions. These grey level variations arise from (a) topographic features, and (b) material differences. In cross section metrology, the desire is to reduce any topographic features so that measurements are based entirely upon the material differences. A common problem however is that the cross sectional have unintended topographic features or "curtaining" which arises from the variability of mill rates for different materials. Figure 1 shows an example of curtaining. Note how the topographic features are revealed as grey level variations which can obscure the grey level variations which arise from material differences.

This invention diminishes the topographic features to a point where they do not affect the metrology. The resulting measurements are more precise and more robust to process variations.

7. Prior Art

How is the problem currently solved? List publications or patents of which you are aware that describe the problem and current solutions.

The alternative is to perform the metrology in a way which ignores the topographic features and tries to measure only the underlying material differences. This requires very careful image processing steps for edge detection. These tend to be not very reliable for SEM images which have large amounts of noise and contrast variations.

There are also a couple of methods to try to reduce the undesired topographic artifacts. One method to reduce the topographic features is to provide a protective overcoat which serves a hard edge mask for the underlying milling. Tungsten (W) is commonly used for this purpose. Another method is to choose a milling angle which reduces the curtaining. This can be achieved by tilting the FIB so that the beam is not parallel to any of the planes which constitute material boundaries.

There are internal FEI technical documents describing W deposition. Other than that, the inventors are not aware of any related patents.

8. Points of Novelty

- *Improve the precision of image based metrology by reducing the topographic artifacts on the cross section face. Ideally the cross section face is perfectly planar.*
- *The topographic artifacts can be reduced by choosing an overcoat whose mill rates (as a function of angle) match the underlying material of interest.*
- *The overcoat can also be selected so that it has a distinctly different electron emission coefficient so that it appears as a distinctly different shade of grey in the SEM image.*

9. **Vendors and customers**
Were vendors or customers involved in the development of the invention? If so, do you know of any agreements with the vendors/customers regarding ownership of intellectual property? Could anyone outside of FEI claim to be an inventor?
No. No. Yes (former employee whose name will be provided soon).

10. **Concise Description of the Invention**
Max. 25 lines and one drawing; add additional material as appendices.

In this invention metrology precision is improved by arranging the cross section face to be free from topographical artifacts such as curtaining. This allows the measurements to be made which are based entirely upon the material differences, rather than topographic features. The topographic features are eliminated by careful matching of the substrate with the overcoat material. Specifically, the mill rates for the two materials are chosen to be as near as possible as a function of the incident FIB angle. This matching is most important at high incident angle (near 90 degrees). In the data storage industry the polepiece materials are often nickel and iron. These materials are well matched by choosing Carbon as an overcoat material. Another criterion for selecting the overcoat material is to choose a material with a significantly different electron emission coefficient. This serves to provide an easily recognizable border between the material of interest and the overcoat material. Carbon is also well suited since it is distinctly darker in the SEM images (see figure 2).

Note that Carbon is not the only material that provides a good match for nickel and iron substrates. Different substrates will require different overcoats. This invention claims a method of choosing the overcoat for each application, rather than choosing a particular overcoat material for any particular application.

Note also that the data for choosing the overcoat (the mill rates at different angles, and the electron emission coefficients) are tabulated in standard references in the public domain.

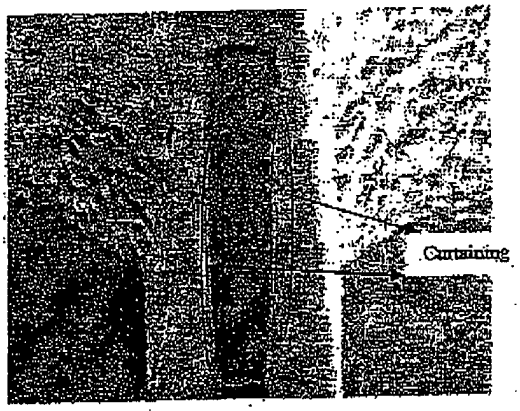

Figure 1. Cross section of a nickel-iron structure which shows distinct vertical topographic features which make the material boundaries difficult to distinguish. The overcoat in this case is tungsten (the lighter material).

SIGNATURES OF INVENTORS AND WITNESSES

(Please note: A patent can be invalidated if the correct inventors are not listed. An inventor contributes to the conception of the claimed invention. A person who exercises "routine skill" in reducing the invention to practice or who supplies well-known information to the inventors is not himself an inventor. It is not necessary to be able to articulate a particular contribution for everyone that was involved in the invention, but inventors cannot be named or omitted for convenience or politics.)

Inventor Signature _____ Date [redacted]
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(Attach additional sheets as needed)

Read and understood by:
(Witnesses should not be involved in the development of the invention)

Witness _____ Date _____
Printed Name:

Witness _____ Date _____
Printed Name: